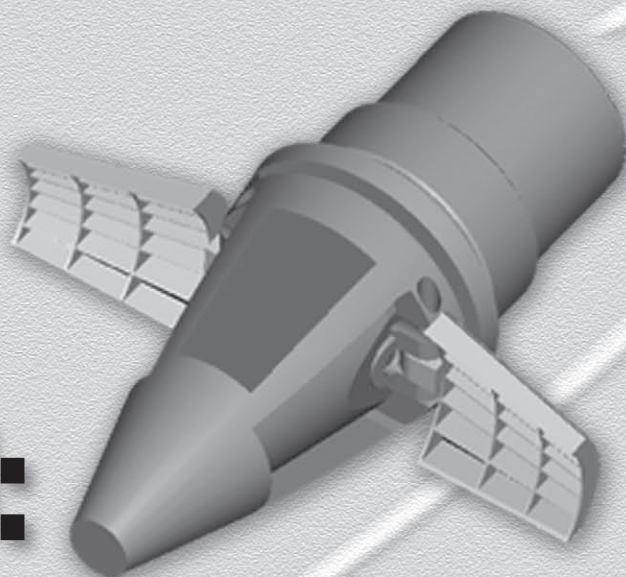


Precision Guidance Kits (PGKs):

Improving the Accuracy of Conventional Cannon Rounds



The near future holds technology that will improve the accuracy of conventional cannon projectiles, or “dumb” rounds, significantly without the high cost required of precision-guided munitions (PGMs), such as Excalibur unitary and others under development for cannon artillery. PGKs employ this technology to improve the accuracy of 155-mm and, eventually, 105-mm conventional cannon rounds. PGK uses a fuze-like global positioning system (GPS) capability to improve the rounds’ accuracy down to 50 meters or less circular error probable (CEP) at all ranges. Increment 1 155-mm PGK is projected for fielding in FY09.

This article explains the PGK requirement, benefits and employment; discusses its complementary role to other munitions; and provides a summary of on-going activities.

Why make dumb rounds smarter? Some may question why we need to make dumb rounds more accurate. The answer: Making some of our conventional cannon projectiles more accurate with PGK gives the ground force commander an additional fire support option that, for many targets, is the most efficient and effective option.

Conventional cannon artillery is an area-fire weapon system with a specified role of providing accurate, responsive fires in support of maneuver. It also may be used to create psychological effects on enemy combatants through volume and concussion. In that case, the more

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rounds the better. The goal for all artillery missions is to achieve the commander’s desired effects.

Although FA cannon units are experts at providing indirect fires, errors exist inherently in the delivery processes that affect the rounds’ accuracy. As a result of these errors, units can experience a large dispersion of rounds around a target. To compensate for this dispersion, FA units must fire many rounds or volleys to increase the probability of attaining the desired lethal effects on the target.

In most cases, the increased volume required to attack a target is an effort to compensate for the inherent inaccuracies of any given indirect fire weapon system.¹ This is a function of accuracy, lethality and sheafing rules in the advanced FA tactical data system (AFATDS). The logic built into AFATDS determines the number of rounds for each mission and is based on attack guidance for each target type as established by the Joint Munitions Effectiveness Manual (JMEM). The harder the target, the more rounds required.

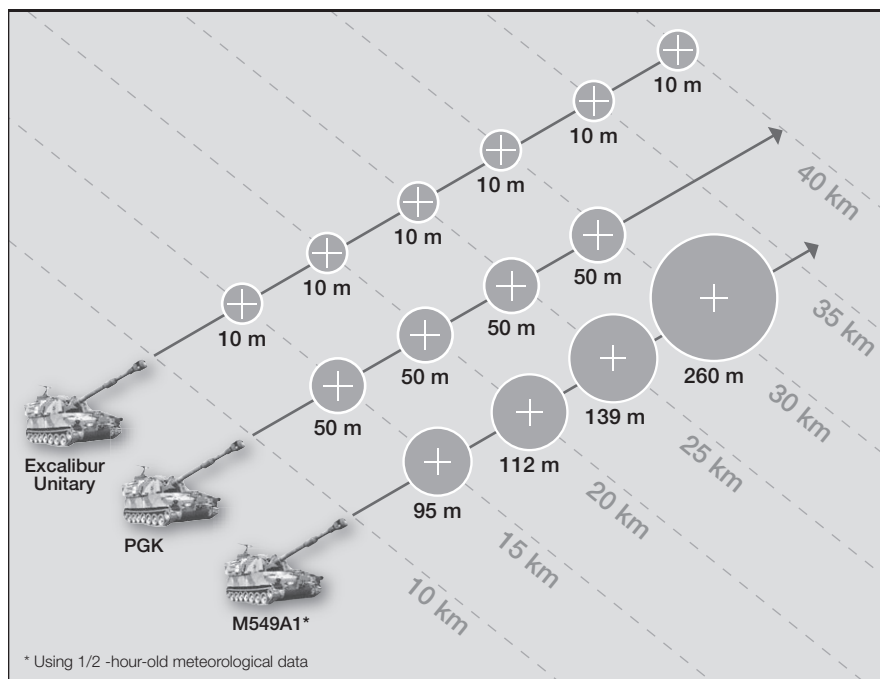
Conventional cannon fires *can* create the desired effects, but the downside is the large expenditure of munitions required to accomplish the mission. Firing more rounds with larger dispersion can result in less than satisfactory effects and increase the potential for unwanted collateral damage, such as noncombatant casualties. The risk of these unintended

consequences often restricts the use of area cannon munitions in many operational environments, such as Iraq. Firing a larger number of rounds also places a larger demand on the supply and transportation systems and forces units to fire for longer periods, increasing their chances of being detected by the enemy and receiving counterfire.

Today, units achieve somewhat greater accuracy with dumb rounds by meeting the five requirements for accurate, predicted fire: accurate target location and size, accurate firing unit location, correct weapon and ammo information, current meteorological (Met) data and correct computational procedures. When units meet these requirements, they can provide relatively accurate FA fires.

Why PGK? PGK increases the accuracy of conventional cannon rounds, thereby, decreasing miss distances (or dispersion). This is the distance between “should hit” and “did hit” locations. The longer the range, the larger the miss distance.² With larger miss distances, fewer rounds impact the target inside the bursting radius of a 155-mm projectile, decreasing lethality and effectiveness.

Miss distances occur in both range and deflection and are due to inherent errors (things we cannot always compensate for in corrections). These errors result from variations in Met data, projectile weight and shape, different gun environments, and even the texture of paint on the projectile. Unfortunately, these errors occur to some degree, even when units



This figure compares 155-mm circular error probable (CEP) and range for a conventional “dumb” round (M549A1, a high-explosive rocket-assisted, or HERA, projectile), a round with a precision guidance kit (PGK) and Excalibur Unitary. Note that the conventional 155-mm round’s CEP gets larger as the range increases.

meet all five requirements for accurate, predicted fires.

PGK will correct for these unknown errors and make dumb rounds more accurate by means of GPS guidance. Without PGK, the CEP for conventional projectiles is a function of range. An M549A1 high-explosive rocket assisted (HERA) projectile fired at 30 kilometers has a 260-meter CEP. Rounds fired at shorter ranges usually have a CEP of 50 meters or less. (See the figure.)

In short, PGK rounds fired at the mid-to-max ranges will be as accurate at 30 kilometers as rounds without PGK are when fired at five and 10 kilometers. CEP with PGK is no longer a function of range. In terms of the example M549A1, if it had PGK, its 260-meter CEP at 30 kilometers would shrink to 50 meters.

In essence, PGK will shrink the miss distance, improve accuracy and result in better overall effectiveness and efficiency. It will ensure rounds impact on a target within their lethal radius, making conventional cannon artillery accurate at all ranges.

What exactly is PGK? Under the current concept, PGK will be a guidance kit that replaces the standard HE burster fuze. It will compensate for probable error in range (PE_r) and PE in deflection (PE_d). It will be a cost-effective way to improve the accuracy of the conventional cannon ammunition inventory without

having to modify the projectiles.

The PGK program has three increments. Increment 1’s design will consist of a fuze-like kit that contains GPS guidance, power supply, control surfaces, electronic circuitry and the fuze function modes of point-detonating and proximity. The Increment 1 objective is to achieve a 50-meter or better CEP. In addition, the new M777A2 lightweight 155-mm howitzer and the M109A6 Paladin must be able to fire the PGK-equipped rounds. PGK also must be compatible with all 155-mm HE projectiles (M107, M795 and M549/A1) and the M203A1 and M232 modular artillery charge system (MACS).

The two follow-on increments will provide additional capabilities. Increment 2 will minimize GPS interference and jamming, improve delivery accuracy to 30 meters, add delay and GPS time-fuze functions, and address the entire 155-mm family of platforms, munitions and propellants.

Increment 3 adds the 105-mm family of platforms, munitions and propellants into the previous design.³ The reason for delaying the 105-mm variant is to synchronize it with the planned M119A2 howitzer digitization program.

When do fire supporters choose PGK for projectiles? Fire supporters must consider capabilities when deciding whether or not to employ PGK: it is simply not cost-effective to use PGK on

short-range missions because it provides very little benefit. This is especially true when units do well at the five requirements for accurate, predicted fires. Also, PGK requires more time for the GPS to acquire and adjust the trajectory than is available during the time-of-flight of short-range missions.

The PGK selection criteria, most likely, will be more complex than for normal fuzes because of its capabilities and limited quantities in unit basic loads (UBLs). Forward observers (FOs) will be able to request PGMs as an option in future versions of the FO software (FOS) with new entries for target descriptions and target areas to help them determine the type of PGM for the mission. What PGK adds to PGMs is scalable precision.

FOs will select PGK only when the mission dictates and circumstances meet the selection criteria established by the fire support cell (FSC). FOs and FSC Soldiers will require training to understand when to choose PGK over conventional fuzes on the battlefield.

Selection criteria will be based on the commander’s guidance and mission, enemy, terrain, troops and time (METT-T) considerations. It may include factors such as maximum allowable target location error (TLE), target type, commander’s intent, munitions availability, minimum acceptable range, conservation of UBL, operational environment, rules of engagement (ROE) or limitation on collateral damage.

TLE is a measure of the accuracy with which a sensor can locate a target and is the difference between the actual and predicted target location.⁴ TLE can be extremely important to the effectiveness of a PGK fire mission. As with any conventional munition or PGM (Excalibur unitary or an M549A1 with PGK), the projectile will miss the target when given a “bad grid” as a result of poor target location.

Because there is a relationship between CEP and TLE, there is an optimal TLE of between 30 and 100 meters for employing PGK to maximize lethality and reduce collateral damage risks. Fire supporters will have to *optimize* target location equipment and use experienced, trained observers to ensure the devices render the smallest possible TLE.

Sensor systems in the field today that can provide accurate target location to 10 meters or less are the second generation forward-looking infrared radar (FLIR) and fire support sensor system (FS³). Sensors that have target location errors larger

than 10 meters are the ground-vehicular laser locator designator (G/VLLD), first generation FLIR Bradley eyesafe laser rangefinder (BELRF) and lightweight laser designator rangefinder (LLDR).

How does PGK operate and function? Handling and storing PGK will differ very little from other fuzes; PGK will have the same dimensions as a standard NATO fuze. The only exception is it may require special handling if the wing-like control surfaces are exposed and fixed in the final solution.

Upon receipt of a fire mission requesting PGK, Cannoneers mate PGK to the projectile in a similar manner as with current fuzes. Using the enhanced portable inductive artillery fuze setter (EPIAFS), Cannoneers set/load (program) the PGK the same as any inductively set fuze, transferring all mission-essential data (fuze mode, howitzer and target location) necessary for PGK to function reliably. It takes less than 10 seconds to pass all the fuze mode and GPS mission data to PGK.

Once fired, the PGK-equipped projectile acquires GPS during flight and follows a normal ballistic trajectory to apogee (top of flight path) where the processor begins calculating the estimated miss distance to determine when to deploy the control surfaces (brakes or canards). At the optimal time during the descending leg of the trajectory, the control surfaces deploy and begin correcting the flight path.

Control surface deployment time is critical. The processor estimates the miss distance and uses the surfaces to make small corrections to the trajectory, guiding it to the intended aim point.

What is unknown at this time is how much control authority (maneuverability) PGK will provide because it guides the projectile to the aim point instead of gliding like Excalibur unitary does. This will be determined through testing. What is certain from analysis is that PGK will make conventional cannon artillery more effective and efficient in performing its mission.

How does PGK complement other munitions on the battlefield? PGK will fit into the ammunition spectrum between unguided dumb rounds used in area-fire missions and the more precise option of Excalibur unitary.

PGK will be considered an "area precision munition," meaning it is an area-fired munition that is more precise than conventional rounds. Target sets are the same as for any HE projectile. Some

targets may be better suited for use with PGK, such as linear targets (bridges, roads and convoys, troops in the open, etc.) or high pay-off targets (HPTs), such as tactical operations centers (TOCs) and command posts (CPs). The targets engaged with PGK, ultimately, will depend on the commander's intent and the mission type.

The conventional unguided dumb rounds will continue to play a key role in the FA arsenal when mission dictates. This is especially true when commanders require the massing of fires to create havoc and destruction and there is little concern with collateral damage.

At the same time, PGK will provide commanders the option of scalable precision to more closely match the round to the task. Instead of firing large numbers of projectiles to attack a target as specified today in AFATDS, the commander will be able to choose PGK to "tighten up the shot group" and achieve the desired effects with fewer rounds. Using PGKs, units will be able to service more targets in the same span of time, resulting in a better overall efficiency and use of UBLs. Firing fewer rounds also will decrease the crews' susceptibility to counterbattery fires, increasing their survivability.

Commanders will be able to select PGK as the munition of choice when mitigation of collateral damage is a concern at extended ranges and precision munitions are neither available nor feasible.⁵ In addition, improved accuracy with PGK could lessen the logistics resupply burden. Depending on the mission, units could sustain fires longer without ammo resupply. This would free transportation assets for other missions on the battlefield.

When will PGK be fielded? The Program Executive Officer, Ammunition (PEO-AMMO) approved the PGK program in December 2005. The Army Requirements Oversight Council (AROC) has approved the PGK requirements document that currently is in the joint staffing process.

Charged with developing PGK, the Project Manager, Combat Ammunition Systems (PM CAS) solicited industry for possible PGK Increment 1 designs that can provide a near-term solution. In the spirit of competition, PM CAS awarded two six-month technology contracts, one to BAE Systems and one to Alliant Techsystems (ATK), for PGK development with a "shoot-off" at Yuma Proving Ground, Arizona, in early spring 2007. PM CAS plans to award the winner of

the shoot-off with a contract for Increment 1. The PM anticipates fielding of Increment 1 sometime in FY09.

PGK's acquisition strategy will follow an incremental developmental approach to prove the concept. Once the program achieves a 50-meter CEP, production will begin for limited quantities of Increment 1 for fielding while development begins on Increment 2.

A long-range goal for Increment 3 is to leverage the 155-mm PGK technologies for PGK use with 105-mm projectiles. The initial version of PGK may be robust enough to meet the 105-mm howitzer requirements, but only time and testing will determine its compatibility.

Today's technology can help achieve area precision effects with fewer rounds. The PGK Team is working to make this capability a reality for Soldiers. As PGK evolves, it will fill a distinct precision gap between conventional cannon rounds and Excalibur unitary, providing commanders the option of scalable precision in combat operations.

Endnotes:

1. Colonels Gary S. Kinne, John A. Tanzi and Jeffrey W. Yaeger, "FA PGMs—Revolutionizing Fires for the Ground Force Commander," *Field Artillery*, May-June 2006, 16-21.
2. Initial Draft, "PGK Tactics, Techniques, and Procedures (TTPs)," Training and Doctrine Command (TRADOC) Capability Manager-Cannon (TCM Cannon), August 2006, 10.
3. "Precision Guidance Kit (PGK) Capabilities Development Document (CDD)," PGK Integrated Product Team, Version 1.3, Para 5—"Program Summary," 15 November 2006, 7.
4. Initial Draft, PGK TTPs, 17.
5. Ibid., 18.

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